

**CLAIMS**

We claim:

1        1. A method of applying a sculptured layer of material on a semiconductor feature  
2        surface using ion deposition sputtering, wherein a surface onto which the sculptured  
3        layer is applied is protected to resist erosion and contamination by impacting ions of a  
4        depositing layer, said method comprising the steps of:

5            a) applying a first portion of a sculptured layer using traditional sputtering or  
6        ion deposition sputtering in combination with sufficiently low substrate bias that a  
7        surface onto which said sculptured layer is applied is not eroded away or contaminated  
8        in an amount which is harmful to said semiconductor feature performance or  
9        longevity; and

10           b) applying a subsequent portion of said sculptured layer using ion deposition  
11        sputtering with sufficiently high substrate bias to sculpture a shape from said the first  
12        portion, while depositing additional layer material.

1        2. The method of Claim 1, wherein said sculptured layer exhibits a substantially  
2        uniform thickness.

1        3. The method of Claim 1 or Claim 2, wherein said sculptured layer is a barrier layer  
2        or a wetting layer.

1        4.. The method of Claim 3, wherein the minimum thickness of said barrier layer or  
2        setting layer at any point on said semiconductor feature surface is about 5 Å.

1        5. The method of Claim 4, wherein said semiconductor feature size is less than about  
2        5 µm with an aspect ratio of at least 1.

1        6. The method of Claim 5, wherein said semiconductor feature size is less than about  
2        0.5  $\mu\text{m}$  with an aspect ratio of at least 3.

1        7. The method of Claim 3, wherein said barrier layer comprises a material selected  
2        from the group consisting of Ta, TaN, TaSiN, Mo, MoN, MoSiN, TiN, TiSiN, W,  
3        WN, WSiN, and combinations thereof.

1        8. The method of Claim 3, wherein said wetting layer comprises a material selected  
2        from the group consisting of Ta, Mo, Ti, and combinations thereof.

1        9. The method of Claim 3, wherein said barrier layer is selected from the group  
2        consisting of Ti, TiN, and combinations thereof.

1        10. The method of Claim 1 or Claim 2, wherein said sculptured layer is a seed layer  
2        of a conductive material.

1        11. The method of Claim 10, wherein said conductive material is selected from the  
2        group consisting of Cu, Al, Ag, Ni, Au, W, and Pt.

1        12. The method of Claim 11, wherein said conductive material is copper.

1        13. The method of Claim 7, minimum thickness of said seed layer at any point on  
2        said semiconductor feature surface is about 5  $\text{\AA}$ .

1        14. The method of Claim 13, wherein said semiconductor feature size is less than  
2        about 5  $\mu\text{m}$  with an aspect ratio of at least 1.

1 15. The method of Claim 14, wherein said semiconductor feature size is less than  
2 about 0.5  $\mu\text{m}$  with an aspect ratio of at least 3.

1 16. The method of Claim 1 or Claim 2, wherein said substrate bias applied during the  
2 deposition of said first portion of said sculptured layer is less than about - 20 V.

1 17. The method of claim 1 or Claim 2, wherein no substrate bias is applied during  
2 the deposition of said first portion of said sculptured layer.

1 18. The method of Claim 1, or Claim 2, wherein said substrate bias applied during  
2 said subsequent portion of said sculptured layer is greater than about - 20 V.

1 19. The method of Claim 17, wherein said substrate bias applied during said  
2 subsequent portion of said sculptured layer is greater than about - 20 V.

1 20. The method of Claim 18, wherein said first portion of said sculptured layer is  
2 deposited using an IMP technique at a process chamber pressure of at least about 1  
3 mT.

1 21. The method of Claim 19, wherein said first portion of said sculptured layer is  
2 deposited using an IMP technique at a process chamber pressure of at least about 1  
3 mT.

1 22. The method of Claim 20, wherein said first portion of said sculptured layer is  
2 deposited using an IMP technique at a process chamber pressure of at least about 10  
3 mT.

1 23. The method of Claim 21, wherein said first portion of said sculptured layer is  
2 deposited using an IMP technique at a process chamber pressure of at least about 10  
3 mT.

1 24. The method of Claim 18, wherein said first portion of said sculptured layer is  
2 deposited using a standard sputtering technique at a process chamber pressure of 10  
3 mT or less.

1 25. The method of Claim 18, wherein said second portion of said sculptured layer is  
2 deposited using an IMP technique at a process chamber pressure of at least about 1  
3 mT.

1 26. The method of Claim 19, wherein said second portion of said sculptured layer is  
2 deposited using an IMP technique at a process chamber pressure of at least about 1  
3 mT.

1 27. The method of Claim 20, wherein said second portion of said sculptured layer is  
2 deposited using an IMP technique at a process chamber pressure of at least about 10  
3 mT.

1 28. The method of Claim 21, wherein said first portion of said sculptured layer is  
2 deposited using an IMP technique at a process chamber pressure of at least about 10  
3 mT.

1 29. The method of Claim 12, wherein said substrate temperature during application of  
2 said copper seed layer is less than about 500 °C.

3 30. The method of Claim 29, wherein said substrate temperature is less than about  
4 200 °C.